

1 CLAIMS:

2 1. A method for cleaning a surface of a semiconductor article,
3 comprising:

4 contacting the surface with an oxidizing solution;

5 , rinsing the surface with a rinsing solution to remove and inhibit
6 further activity of the oxidizing solution;

7 exposing the surface to an oxide removal vapor which comprises at
8 least hydrogen halide vapor, to remove semiconductor oxide from the
9 surface.

10
11 2. The method of claim 1 and further comprising drying the
12 surface after the rinsing step and before the exposing step.

13
14 3. The method of claim 1 and further comprising drying the
15 surface after the rinsing step and before the exposing step;

16 and wherein the exposing step is performed without wetting the
17 surface.

18
19 4. The method of claim 1 wherein the oxidizing solution
20 comprises sulfuric acid and hydrogen peroxide.

21
22 5. The method of claim 1 wherein the oxidizing solution
23 comprises sulfuric acid, hydrogen peroxide and water.
24

1 6. The method of claim 1 wherein the oxidizing solution
2 comprises sulfuric acid, hydrogen peroxide, water and ozone.

3
4 7. The method of claim 1 wherein the oxidizing solution
A-53 comprises ~~sulfuric acid~~ and ozone.

6
7 8. The method of claim 1 wherein the oxidizing solution
8 comprises ozone, and provided that the oxidizing solution does not
9 comprise sulfuric acid.

10
11 9. The method of claim 1 wherein the oxidizing solution is a
12 solution of ozone in water.

13
14 10. The method of claim 1 wherein the oxidizing solution
15 comprises hydrogen chloride.

16
17 11. The method of claim 1 wherein the oxidizing solution
18 comprises hydrogen chloride and water.

19
20 12. The method of claim 1 wherein the oxidizing solution
21 comprises hydrogen chloride and ozone.

1 13. The method of claim 1 wherein the oxidizing solution
2 comprises hydrogen chloride, water and ozone.

3
4 14. The method of claim 1 wherein the rinsing solution is water.

5
6 15. The method of claim 1 wherein the oxide removal vapor
7 comprises hydrogen fluoride vapor.

8
9 16. The method of claim 1 wherein the oxide removal vapor
10 comprises hydrogen fluoride vapor and isopropyl alcohol vapor.

11
12 17. The method of claim 1 wherein the oxide removal vapor
13 comprises hydrogen fluoride vapor and water vapor.

14
15 18. The method of claim 1 wherein the oxide removal vapor
16 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and water
17 vapor.

18
19 19. The method of claim 1 wherein the oxide removal vapor
20 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and an acid
21 vapor other than hydrogen fluoride vapor.

1 20. The method of claim 1 wherein the oxide removal vapor
2 *further*
3 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and hydrogen
4 chloride vapor.

5 21. The method of claim 1 wherein the oxide removal vapor
6 *further*
7 comprises hydrogen fluoride vapor, isopropyl alcohol vapor, hydrogen
8 chloride vapor and water vapor.

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9 22. The method of claim 1 wherein the oxide removal vapor
10 *further*
11 comprises hydrogen fluoride vapor and ~~ozone~~.

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12 23. The method of claim 1 wherein the oxide removal vapor
13 *further*
14 comprises hydrogen fluoride vapor, water vapor and ~~ozone~~.

15 24. The method of claim 1 and further comprising rotating the
16 semiconductor article while performing at least one of said contacting,
17 rinsing or exposing steps.

18
19 25. The method of claim 1 and further comprising rotating the
20 semiconductor article while performing at least one of said contacting,
21 rinsing or exposing steps;

22 and wherein at least one of said contacting or rinsing steps is
23 performed by spraying liquids upon the surface.
24

1 26. A method for cleaning a surface of a silicon semiconductor
2 article, comprising:

3 contacting the surface with an oxidizing solution which includes
4 sulfuric acid and ozone;

5 , rinsing the surface with a rinsing solution to remove and inhibit
6 further activity of the oxidizing solution;

7 drying the surface;

8 exposing the surface after said drying step to an oxide removal
9 vapor which comprises at least hydrogen fluoride vapor, to remove
10 semiconductor oxide from the surface.

11
12 27. The method of claim 26 wherein the exposing step is
13 performed without wetting the surface.

14
15 28. The method of claim 26 wherein the contacting step is
16 performed at a temperature in the range from about 50°C to about 150°C.

17
18 29. The method of claim 26 wherein the contacting step is
19 performed at a temperature in the range from about 90°C to about 140°C.

20
21 30. The method of claim 26 wherein the oxidizing solution further
22 comprises hydrogen peroxide.

1 31. The method of claim 26 wherein the oxidizing solution further
2 comprises hydrogen peroxide and water.

3
4 32. The method of claim 26 wherein the rinsing solution is water.

5
6 33. The method of claim 26 wherein the oxide removal vapor
7 further comprises isopropyl alcohol vapor.

8
9 34. The method of claim 26 wherein the oxide removal vapor
10 further comprises water vapor.

11
12 35. The method of claim 26 wherein the oxide removal vapor
13 further comprises isopropyl alcohol vapor and water vapor.

14
15 36. The method of claim 26 wherein the oxide removal vapor
16 further comprises isopropyl alcohol vapor and an acid vapor, other than
17 hydrogen fluoride vapor.

18
19 37. The method of claim 26 wherein the oxide removal vapor
20 further comprises isopropyl alcohol vapor and hydrogen chloride vapor.

1 38. The method of claim 26 wherein the oxide removal vapor
2 further comprises isopropyl alcohol vapor, hydrogen chloride vapor and
3 water vapor.

4
5 39. The method of claim 26 wherein the oxide removal vapor
6 comprises hydrogen fluoride vapor and ozone.

7
8 40. The method of claim 26 wherein the oxide removal vapor
9 comprises hydrogen fluoride vapor, water vapor and ozone.

10
11 41. The method of claim 26 wherein the oxide removal vapor
12 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and ozone.

13
14 42. The method of claim 26 and further comprising rotating the
15 semiconductor article while performing at least one of said contacting,
16 rinsing, drying, or exposing steps.

17
18 43. The method of claim 26 and further comprising rotating the
19 semiconductor article while performing at least one of said contacting,
20 rinsing, drying, or exposing steps;

21 and wherein at least one of said contacting or rinsing steps is
22 performed by spraying liquids upon the surface.

1 44. A method for cleaning a surface of a silicon semiconductor
2 article, comprising:

3 contacting the surface with an oxidizing solution which includes
4 hydrogen chloride acid and ozone;

5 rinsing the surface with a rinsing solution to remove and inhibit
6 further activity of the oxidizing solution;

7 drying the surface;

8 exposing the surface after said drying step to an oxide removal
9 vapor which comprises at least hydrogen fluoride vapor, to remove
10 semiconductor oxide from the surface.

11
12 45. The method of claim 44 wherein the exposing step is
13 performed without wetting the surface.

14
15 46. The method of claim 44 wherein the oxidizing solution further
16 comprises water.

17
18 47. The method of claim 44 wherein the rinsing solution is water.

19
20 48. The method of claim 44 wherein the oxide removal vapor
21 comprises hydrogen fluoride vapor and isopropyl alcohol vapor.
22
23
24

1 49. The method of claim 44 wherein the oxide removal vapor
2 comprises hydrogen fluoride vapor and water vapor.

3
4 50. The method of claim 44 wherein the oxide removal vapor
5 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and water
6 vapor.

7
8 51. The method of claim 44 wherein the oxide removal vapor
9 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and an acid
10 vapor other than hydrogen fluoride vapor.

11
12 52. The method of claim 44 wherein the oxide removal vapor
13 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and hydrogen
14 chloride vapor.

15
16 53. The method of claim 44 wherein the oxide removal vapor
17 comprises hydrogen fluoride vapor, isopropyl alcohol vapor, hydrogen
18 chloride vapor and water vapor.

19
20 54. The method of claim 44 wherein the oxide removal vapor
21 comprises hydrogen fluoride vapor and ozone.

1 55. The method of claim 44 wherein the oxide removal vapor
2 comprises hydrogen fluoride vapor, water vapor and ozone.

3
4 56. The method of claim 44 wherein the oxide removal vapor
5 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and ozone.

6
7 57. The method of claim 44 and further comprising rotating the
8 semiconductor article while performing at least one of said contacting,
9 rinsing, drying, or exposing steps.

10
11 58. The method of claim 44 and further comprising rotating the
12 semiconductor article while performing at least one of said contacting,
13 rinsing, drying, or exposing steps;

14 and wherein at least one of said contacting or rinsing steps is
15 performed by spraying liquids upon the surface.

59. A method for cleaning a surface of a semiconductor article,
comprising:

contacting the surface with an oxidizing solution containing ozone;
rinsing the oxidizing solution from the surface to remove and inhibit
further activity of the oxidizing solution;

A-6 ~~drying the surface after the rinsing step;~~

exposing the surface to an oxide removal vapor which removes
semiconductor oxide from the surface.

60. The method of claim 59 wherein the exposing step is
performed without wetting the surface.

B-2 61. The method of claim 59 wherein the oxidizing solution ^{*further*} *sulfuric*
comprises sulfuric acid and hydrogen peroxide.

B-2 62. The method of claim 59 wherein the oxidizing solution ^{*further*} *sulfuric*
comprises sulfuric acid, hydrogen peroxide and water.

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B-1 63. The method of claim 59 wherein the oxidizing solution ^{*further*} *sulfuric*
comprises sulfuric acid, hydrogen peroxide, water and ozone.

64. The method of claim 59 wherein the oxidizing solution
comprises sulfuric acid and ozone.

1 65. The method of claim 59 wherein the oxidizing solution is a
2 solution of ozone in water.

3
4 66. The method of claim 59 wherein the oxidizing solution *further*
5 comprises hydrogen chloride. *function*

6
7 *B-2* 67. The method of claim 59 wherein the oxidizing solution *further*
8 comprises hydrogen chloride and water. *function*

9
10 **CANCELLED** 68. The method of claim 59 wherein the oxidizing solution *cancel*
11 comprises hydrogen chloride and ozone. *B-1*

12 **CANCELLED**
13 *B-1* 69. The method of claim 59 wherein the oxidizing solution *cancel*
14 comprises hydrogen chloride, water and ozone.

15
16 70. The method of claim 59 wherein the rinsing solution is water.

17
18 71. The method of claim 59 wherein the oxide removal vapor
19 comprises hydrogen fluoride vapor.

20
21 72. The method of claim 59 wherein the oxide removal vapor
22 comprises hydrogen fluoride vapor and isopropyl alcohol vapor.
23
24

1 73. The method of claim 59 wherein the oxide removal vapor
2 comprises hydrogen fluoride vapor and water vapor.

3
4 74. The method of claim 59 wherein the oxide removal vapor
5 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and water
6 vapor.

7
8 75. The method of claim 59 wherein the oxide removal vapor
9 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and an acid
10 vapor other than hydrogen fluoride vapor.

11
12 76. The method of claim 59 wherein the oxide removal vapor
13 comprises hydrogen fluoride vapor, isopropyl alcohol vapor and hydrogen
14 chloride vapor.

15
16 77. The method of claim 59 wherein the oxide removal vapor
17 comprises hydrogen fluoride vapor, isopropyl alcohol vapor, hydrogen
18 chloride vapor and water vapor.

19
20 78. The method of claim 59 wherein the oxide removal vapor
21 comprises ~~hydrogen fluoride vapor and ozone.~~
22
23
24

1 79. The method of claim 59 wherein the oxide removal vapor
2 comprises hydrogen fluoride vapor, water vapor and ozone.

3
4 80. The method of claim 59 and further comprising rotating the
5 semiconductor article while performing at least one of said contacting,
6 rinsing, drying, or exposing steps.

7
8 81. The method of claim 59 and further comprising rotating the
9 semiconductor article while performing at least one of said contacting,
10 rinsing, drying, or exposing steps;

11 and wherein at least one of said contacting or rinsing steps is
12 performed by spraying liquids upon the surface.

13
14 ~~CANCELLED~~ 82. A method for cleaning a surface of a semiconductor article,
15 A-1 comprising contacting the surface with an oxidizing solution comprising
16 hydrogen chloride and ozone.

17
18 ~~CANCELLED~~ 83. A method according to claim 82 wherein the oxidizing solution
19 A-1 further comprises water.

20
21 A-1 84. A method for cleaning a surface of a semiconductor article,
22 comprising contacting the surface with an oxidizing solution comprising
23 sulfuric acid and ozone.

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85. A method according to claim 84 wherein the oxidizing solution further comprises water.

86. A method for cleaning a surface of a semiconductor article, comprising exposing the surface to an oxide removal vapor which comprises hydrogen fluoride vapor and ozone vapor.

87. A method according to claim 86 wherein the oxide removal vapor further comprises water.

88. A method for cleaning a surface of a semiconductor article, comprising exposing the surface to an aqueous solution containing ozone and a metals solubilizing agent.

89. A method according to claim 88 wherein the metals solubilizing agent includes at least one hydrogen halide.

90. A method according to claim 88 wherein the metals solubilizing agent includes hydrogen chloride.

A-8 Please add new claims 91-93

B-3 " " " " 94-100